

al
reference signal in the synthesizing processor 32. The phase wave detected signals at a real part and an imaginary part are delivered to the filter 32.

IN THE CLAIMS

Please cancel Claim 21 without prejudice.

Please amend Claims 1-20 to read as follows:¹

A² --1. (Amended) An ultrasonic diagnostic apparatus for scanning a subject to be examined with an ultrasonic pulse, the apparatus comprising:

transmitting means for transmitting the ultrasonic pulse a plurality of times along each scanning line set to a region to be scanned in the subject in order to produce a single image of the region, a transmission characteristic of the ultrasonic pulse transmitted every time the ultrasonic pulse is transmitted along each scanning line for producing the image being different from one another;

receiving means for receiving an ultrasonic echo signal returned when the ultrasonic pulse is reflected or scattered in the subject, and acquiring an electrical reception signal that corresponds to the ultrasonic echo signal;

filter means for applying filtering processing to each reception signal acquired by the receiving means, a characteristic of the filtering processing applied to each of the reception signals acquired along each scanning line being different from one another;

synthesizing means for synthesizing the plurality of reception signals, scanning line by scanning line, filtering-processed by the filter means;

producing means for producing image data of the region using the reception signals synthesized by the synthesizing means; and

¹A marked-up copy of the changes made to these claims is attached.

display means for displaying the image data produced by the producing means.

12 ~~2~~ (Amended) The ultrasonic diagnostic apparatus as claimed in claim ~~22~~^{11 21}, wherein the transmitting unit is configured to change a center frequency of the ultrasonic pulse every time the ultrasonic pulse is transmitted along each scanning line in order to produce the image.

13 ~~3~~ (Amended) The ultrasonic diagnostic apparatus as claimed in claim ~~22~~^{11 21}, wherein the transmitting unit is configured to transmit the ultrasonic pulse of which frequency bandwidth is narrow to an extent such that a signal component of the reception signal corresponding to a harmonic component of the ultrasonic pulse that has been transmitted is separable from a signal component of the reception signal corresponding to a fundamental component of the ultrasonic pulse that has been transmitted.

14 ~~4~~ (Amended) The ultrasonic diagnostic apparatus as claimed in claim ~~22~~^{11 21}, wherein the filter is configured to sample, every time the ultrasonic pulse is transmitted, from the reception signal, a signal component corresponding to a harmonic component of the ultrasonic pulse that has been transmitted and the synthesizing unit is configured to mutually synthesize the harmonic components filtered by the filter in response to transmitting the ultrasonic pulse along each scanning line for producing the image.

15 ~~5~~ (Amended) The ultrasonic diagnostic apparatus as claimed in claim ~~4~~¹⁴, wherein the signal component corresponding to the harmonic component, which is synthesized by the synthesizing unit, is broader in a bandwidth than the harmonic component obtained by one time of both the transmission/reception and the filtering processing.

16 ~~6~~ (Amended) The ultrasonic diagnostic apparatus as claimed in claim ~~4~~¹⁴, wherein the harmonic component is a signal component that corresponds to a sub-harmonic component of

the ultrasonic pulse, the sub-harmonic component being generated due to a non-linear behavior of an ultrasonic contrast medium administered into the subject.

AL 17 ~~7~~¹⁴ (Amended) The ultrasonic diagnostic apparatus as claimed in claim ~~4~~¹⁴, wherein the filter is configured to change the characteristic of the filtering processing according to a depth in a direction of each scanning line direction, the characteristic of the filtering processing being determined so that a predetermined amount of a signal component corresponding to a fundamental component of the ultrasonic pulse is positively left in a filtered signal.

18 ~~8~~^{11 21} (Amended) The ultrasonic diagnostic apparatus as claimed in claim ~~22~~^{11 21}, wherein the synthesizing unit is configured to add the plurality of reception signals filtering-processed by the filter correspondingly to each scanning line.

19 ~~9~~^{11 21} (Amended) The ultrasonic diagnostic apparatus as claimed in claim ~~22~~^{11 21}, further comprising a changing unit configured to change, every time the ultrasonic pulse is repeatedly transmitted along each scanning line a plurality of times, at least one of parameters including a center frequency and a frequency bandwidth of the ultrasonic pulse, an amplitude of the ultrasonic pulse, an aperture for transmitting the ultrasonic pulse, a focus obtained when the ultrasonic pulse is beam-formed, a receiving gain for the reception signal, and an addition coefficient for obtaining the reception signal.

20 ~~10~~^{11 21} (Amended) The ultrasonic diagnostic apparatus as claimed in claim ~~22~~^{11 21}, wherein the transmitting unit is configured to transmit the ultrasonic pulse having a frequency bandwidth at which a first signal component of the reception signal corresponding to a harmonic component of the ultrasonic pulse and a second signal component of the reception signal corresponding to a fundamental component of the ultrasonic pulse are partially

overlapped on each other with regard to spectra of the first and second signal components,
and

the filter is configured to extract, from the reception signal, every time of transmitting the ultrasonic pulse, a signal component having a frequency range falling in a frequency range of the harmonic component, but being outside an overlapped frequency range on the fundamental component.

A² 21 11. (Amended) The ultrasonic diagnostic apparatus as claimed in claim 22, wherein the transmitting unit is configured to change both of the number of times of transmission of the ultrasonic pulse to be transmitted and a center frequency of the ultrasonic pulse to be transmitted each time so that physiological attenuation occurring when the ultrasonic pulse and the ultrasonic echo signal propagate through the subject is corrected in the reception signal synthesized by the synthesizing unit.

2 12. (Amended) An ultrasonic diagnostic apparatus for scanning a subject to be examined with an ultrasonic pulse, thereby acquiring a harmonic image, said apparatus comprising:

a transmitting unit configured to transmit the ultrasonic pulse a plurality of times along each scanning line set to a region to be scanned in the subject in order to produce a single image of the region, the ultrasonic pulse having a narrow-bandwidth spectrum characteristic set to such an extent that a signal component corresponding to a harmonic component of the ultrasonic pulse is separable from a signal component corresponding to a fundamental component of the ultrasound pulse;

a receiving/processing unit configured to receive an echo signal of the ultrasonic pulse responsively to each of the plurality of times of transmission of the ultrasonic pulse

along each scanning line, and processing the echo signal received each time into a harmonic signal having a broader-bandwidth spectrum characteristic; and

an image producing unit configured to produce a harmonic image from the harmonic signal.

A² 3 ~~13~~. (Amended) An ultrasonic imaging method in which a subject to be examined is scanned by an ultrasonic pulse transmitted, an electrical reception signal that corresponds to an ultrasonic echo signal returned when the ultrasonic pulse is reflected or scattered in the subject is acquired, and an image of a region scanned in the subject is obtained from the reception signal, said method comprising the steps of:

executing transmission of the ultrasonic pulse, reception of the echo signal, and acquisition of the reception signal, the transmission and the reception being carried out a plurality of times along each scanning line forming the region to be scanned in order to produce a single image of the region;

applying filtering processing to each reception signal acquired, a characteristic of the filtering processing applied to each of the reception signals acquired along each scanning line being different from one another;

synthesizing the plurality of processed reception signals with each other, scanning line by scanning line;

producing image data of the region scanned by using the synthesized reception signals; and

displaying an image based on the produced image data.

4 14. (Amended) The ultrasonic imaging method as claimed in claim ³~~13~~, wherein the transmitted ultrasonic pulse is different from each other with respect to a center frequency thereof every time the ultrasonic pulse is transmitted along each scanning line.

A2 5 ~~15~~. (Amended) The ultrasonic imaging method as claimed in claim ~~13~~³, wherein the transmitted ultrasonic pulse has a narrow frequency bandwidth set to such an extent that a signal component of the reception signal corresponding to a harmonic component of the ultrasonic pulse is separable from a signal component of the reception signal corresponding to a fundamental component of the ultrasonic pulse.

7 ~~16~~. (Amended) The ultrasonic diagnostic apparatus as claimed in claim ~~13~~³, wherein the filtering processing is set to a process for sampling, every time the ultrasonic pulse is transmitted, from the reception signal, a signal component that corresponds to a harmonic component of the ultrasonic pulse.

8 ~~17~~. (Amended) The ultrasonic diagnostic apparatus as claimed in claim ~~16~~⁷, wherein the signal component corresponding to the harmonic component, which is synthesized at the synthesizing step is broader in a bandwidth than the harmonic component obtained by one time of both the transmission/reception and the filtering processing.

6 ~~18~~. (Amended) The ultrasonic diagnostic apparatus as claimed in claim ~~15~~⁵, wherein the harmonic component corresponds to a second harmonic component of the ultrasonic pulse generated due to either a non-linearity of physiological tissues of the subject or a non-linear behavior of an ultrasonic contrast medium administrated into the subject.

9 ~~19~~. (Amended) The ultrasonic diagnostic apparatus as claimed in claim ~~13~~³, further comprising the step of changing, every time the ultrasonic pulse is repeatedly transmitted along each scanning line a plurality of times, at least one of parameters including a center frequency and a frequency bandwidth of the ultrasonic pulse; an amplitude of the ultrasonic pulse; an aperture for transmitting the ultrasonic pulse; a focus obtained when the ultrasonic pulse is beam-formed; a receiving gain for the reception signal; and an addition coefficient for obtaining the reception signal.

10 ~~20~~. (Amended) An ultrasonic diagnostic apparatus for scanning a subject to be examined with an ultrasonic pulse in order to acquire a harmonic image of the subject, said apparatus comprising:

A² a transmitting unit configured to transmit the ultrasonic pulse a plurality of times along each scanning line set to a region to be scanned in the subject in order to produce a single image of the region, the plurality of times of the ultrasonic pulses to be transmitted including two types of the ultrasonic pulses of which signal polarities are opposite to each other, each type of the ultrasonic pulse being further transmitted a plurality of times, a transmission characteristic of the ultrasound pulse belonging to each type being different one from the other;

a receiving unit configured to receive an electrical reception signal that corresponds to an ultrasonic echo signal returned from the subject every time of transmission of the ultrasonic pulse;

a synthesizing unit configured to mutually add, between the two types of transmission, the reception signals to produce a plurality of harmonic components depending on the restrictive transmission characteristics and to mutually synthesize, every type of transmission, the plurality of harmonic components to broaden a bandwidth of the harmonic component relevant to a fundamental component of the ultrasonic pulse; and

an image producing unit configured to produce the harmonic image from the harmonic component of which bandwidth is broadened by the synthesizing unit.

☐ Please add new Claim 22 as follows:

11 ~~21~~ ~~22~~. (New) An ultrasonic diagnostic apparatus for scanning a subject to be examined with an ultrasonic pulse, the apparatus comprising:

A³

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cont

a transmitting unit configured to transmit the ultrasonic pulse a plurality of times along each scanning line set to a region to be scanned in the subject to produce a single image of the region, a transmission characteristic of the ultrasonic pulse transmitted every time the ultrasonic pulse is transmitted along each scanning line for producing the image being different from one another;

a receiving unit configured to receive an ultrasonic echo signal returned from the region of the subject and to acquire an electrical reception signal corresponding to the ultrasonic echo signal;

a filter configured to apply filtering processing to each reception signal acquired by the receiving unit, a characteristic of the filtering processing applied to each of the reception signals acquired along each scanning line being different from one another; and

a synthesizing unit configured to synthesize the plurality of reception signals, scanning line by scanning line, filtering-processed by the filter.

REMARKS

Favorable reconsideration of this application as presently amended and in light of the following discussion is respectfully requested.

Claims 1-20 and 22 are pending in the present application. Claims 1-20 have been amended, Claim 21 has been canceled and Claim 22 has been added by the present amendment.

In the outstanding Office Action, Claims 1-8 were rejected under 35 U.S.C. § 102(e) as anticipated by Christopher; Claims 20 and 21 were rejected under 35 U.S.C. § 103(a) as unpatentable over Christopher in view of Averkiou et al; Claims 9-11 were indicated as allowable if rewritten in independent form; and Claims 12-19 were allowed.